DYNAMIC TIMETABLE GENERATOR USING PARTICLE SWARM OPTIMIZATION (PSO) METHOD

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ABSTRACT

This paper addresses the usage of Particle Swarm Optimization (PSO) in generating a timetable which the selection of driver and vehicle are based on the concept of PSO. The objectives are simultaneously considered as follow: 1) minimizing the cycle time, 2) regenerate the timetable. Searching for an optimal solution in such of large sized population will be time consuming and thus by presenting the PSO method is able to select the appropriate driver and vehicle with a shorter period. The timetable that is generated will be more appropriate as regenerating function can handle emergency such as breakdown of vehicle. Besides, during the generating of timetable, it also considers constraints which make the task more challenging. The chosen particle during implementing the PSO method should be chosen with fitness nearest to fifty in this system. Thus, the timetable for transport schedule system can be arranged without clashing of driver or vehicle.

ABSTRAK

Dalam kertas ini mengatakan bahawa kegunaan konsep “Particle Swarm Optimization (PSO)” dalam memilih seorang pamandu dan kenderaan untuk setiap perjalanan. Objektif untuk tajuk ini adalah dianggap seperti berikut: 1) mengurangkan tempoh masa, 2) menjana semula jadual. Dalam populasi yang besar, cara penyelesaian masalah yang optimum akan menggunakan masa yang lama. Jadi, cara PSO telah dikemukakan untuk memilih pemandu dan kenderaan yang sesuai dalam masa yang lebih pendek. Selain itu, jadual yang telah dihasilkan boleh digenerasi semula jika ada sebarang kecemasan berlaku seperti kerosakan kenderaan. Tambahan pula, semasa penjanaan jadual tersebut, kekangan juga akan diambil kira yang menyebabkan tugas penghasilan jadual ini lebih mencabar. Semasa kaedah PSO ini dijalankan, zarah yang mempunyai nilai yang berdekatan dengan lima puluh akan dipilih. Justeru, jadual untuk sistem jadual pengangkutan boleh diatur tanpa bertempur pemandu atau kenderaan.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

UMP – University Malaysia Pahang

PSO – Particle Swarm Optimization

RAD – Rapid Application Development

LIST OF APPENDICES

Chapter I

Introduction

1.1 Introduction

Timetabling problems have been discovered in these recent years and obviously there is an increased level of research activity in this area. There are variety types of timetabling problems arise such as educational timetabling, nurse timetabling and transportation timetabling.Timetabling is an arrangement of time for some events so that it fulfills the tasks given in the event. Timetabling is important to make sure the flow of the timetable can be smooth and success and at the meantime it does not occur any time conflict between each other.

In this transportation timetabling, the condition of drivers and vehicles need to consider so that the timetable generated can fulfill the needs of the user. In this case, an approach which is suitable to solve this situation is preferred to handle any sudden changes.In addition, the number of passengers will be considered for every trip from one station to other station so that it can fit all the passengers listed for every trip.

Particle Swarm Optimisation (PSO) is a self-adaptive global search optimization techniques introduced by J. Kennedy and R. Eberhart[1]. PSO is an artificial intelligence technique which is used to find an approximate solution in a numeric maximization and minimization problems. The model of PSO is most likely as the nature of bird flocking and fish schooling. The concept of PSO is implemented using the stochastic nature of the particle and it’s converging to global with a reasonable solution on the particular problem. PSO is well-known and common in the artificial intelligence field due to its effectiveness in wide range of application, simplicity and lower cost.

1.2 Problem Statement

There is a need to consider the availability of drivers and vehicles of a bus station in order to generate a suitable timetable.For an example, if the driver is available while the vehicles have are not available of a particular bus station, then the timetable need to be rearranged so that it can fulfill the task given. Therefore, the changes in drivers and vehicles availability need to be considered so that a replacement can be made immediately in order to run the timetable successfully.

With the method PSO used, it will generate a timetable through the selection of driver in random with certain condition and match with the vehicles available and come out with a satisfied result. In order to have the result which is satisfy by the user, some constraints need to be fulfilled such as the availability of drivers and the condition of vehicles to prevent the delay of the departure time. In order to present the result in satisfactory, the searching for the driver and vehicle is not only in the particular station but also other station from other area which means distributed driver and vehicles in term of PSO. However, heuristic method is not applicable with a distributed driver and vehicles.

1.3 Scope

The timetable is generated based on the availability of driver and vehicles in a particular station. The process is generated through a method call Particle Swarm Optimization (PSO) which will search for the driver and vehicles that available for the timetable. In case, if a driver is sick suddenly for that day, it will make replacement automatically from the list of other driver so that the timetable can run as usual. Besides, the number of passengers is also considered in order to choose the bus which can fit all the passengers. The appropriate selection of vehicles according with the number of passengers will be made.

1.4 Objectives

1. To generate a timetable in a system by using the PSO method.
2. To enables the user make replacement of driver or vehicle using the PSO method if necessary.

1.5 Thesis Organization

Thesis organization explains about the content that is included in every chapter so that the user can get the rough idea for each chapter. In Chapter 1Introduction, explanation about the project is written to the users so that users can roughly get the ideas of the proposed project.

In Chapter 2 Literature Review, references are found for the project in order to makes sure that the project is done with prove.

In Chapter 3 Methodology, method used for the project will be discussed in order to get the framework of the project.

In Chapter 4 Design, this phase of the thesis is to develop out the framework or system of the project to the user.

In Chapter 5 Implementation, at this phase the workout of the project is being developed and the processes involved is recorded.

In Chapter 6 Results and Discussion will discuss about the results that being implemented to make sure that the outcome is fulfill the user need.

In Chapter 7 Conclusion is to make the summary about the project and the research that have been done.

Chapter II

Literature Review

2.1 Introduction

The problem for this paper has its origin in bus timetabling system for a particular bus station. It requires the selection of a driver and vehicles so that it can produce a timetable which satisfies the requirements Besides, the number of passengers for a slot of time is also considered so that the type of vehicles is chosen appropriately for each slot of time. By assigning the selected driver and vehicles into a particular time slot need to be considered thoroughly and along with the frequency of the service so that the driver get enough rest before the scheduled timetable start.

Particle Swarm Optimisation (PSO) is a self-adaptive global search optimisation technique introduced by Kennedy and Eberhart which has the algorithm that similar to other population-based algorithms like Genetic algorithms but there is random combination of individuals of the population [2].

2.2 Background of Study

There are a lot of research have been carried out about the methods of generating a timetable using different kind of algorithms. A good timetabling of an event can always make sure the flow of the event to run smoothly and there is always a challenging issue for the developer to create a timetable using the appropriate artificial intelligence technique. In this case study, there are a lot of field to be studied such as the educational timetabling [3], sport timetabling [4] and transportation timetabling [5].

In transportation timetabling, the factors that need to be considered are drivers and vehicles to make an optimum timetable. Due to the constraint of the working hour of a driver along with other constraints, scheduling has it difficulty to be created with the constraint included.

Driver constraint that insisted the most is the working hour per day. The driver should not work continuously without any rest as they need to drive from one station to another station safely. The constraint of vehicles is the condition of the vehicle so that it will not happen any accident along the trip. Besides, the size of a vehicle should also be considered so that the number of passengers is able to fit into the vehicle.

2.3 Artificial Intelligence Technique

Artificial Intelligence (AI) technique is a language which can only be read by the computer and the code that deploy by the programmer into the computer will be executed. The program will take the input from the user and display the result in the form of number after the constraints have been included. The different type of AI techniques will display different type of result as the decision made is altered with the constraints included and based on the user demand.

2.4 Particle Swarm Optimization

The particle swarm optimizer (PSO) algorithm is first present by Dr. Kennedy and Dr.Eberhart, and is a random evolution method based on intelligent search of the group birds. It has quick convergence speed and optimal searching ability for solving large-scale optimization problems [6]. Particle Swarm Optimization (PSO) is a computational method which simulates a problem with particles and moving these particles in a given search space based on a mathematical formulae over the particle’s position and velocity.

2.4.1 The Flow of PSO

In Particle Swarm Optimization (PSO), the problem is solved by defining a number of particles in a search space for the processing of the objective function at its current position. The movement of the particles will be determined by combining it with the best fitness location randomly.

The dimension of PSO can be classified into three parts which are current position x_i, previous best position p_i, and the velocity v_{id}. For each individual in particle swarm will possess the three D-dimension of vectors, the D refers to the dimension of the search space.

As the iteration starts, it will evaluate the current position x_{id}as the problem solution. The current position $x_i$will contain the coordinate of a particle in the search space. Once the iteration ends, it will determine whether the current position of the particle is still the best position. If it is, the position will be saved for the next vector p_{id}.

After the position has been saved, in the next iteration, it will be named as previous best position $pbest_{id}$ and taken for the next iterations in order to get a better result. As the iteration keeps going, it will keep updating the value of the p_{id} and $pbest_{id}$.

At this moment, the vector $v_i$will be adjusted and add to the current position x_{id}. Hence, a new point will be selected. Once the local iteration ends, if the vector p_{id} calculated is the best among the local then it will be compared among the global. If the vector is the best among the global then it will automatically be chosen as the best among global p_{gd}.

2.4.2 Particle Swarm Optimization Process

1. Initialize population in search space.
2. Evaluate fitness of individual particles.
3. Modify velocities based on previous best and global (or neighborhood) best.
4. Terminate on some condition.
5. Go to step 2.

$$v_{id} = w_{id}v_{id} + c_1 rand()(p_{id} - x_{id}) + c2Rand()(p_{gd} - x_{id})$$

$$x_{id} = x_{id} + v_{id}$$

where d is the dimension,

c_1 and c_2 are positive constants,

rand and Rand are random function,

w is the inertia weight,

v_i is the velocity,

x_i is the current position,

p_i is the previous local position,

p_g is the previous global position.

2.4.3 Constriction Factor Version of PSO

$$v_{id} = K*[\ w_{id}v_{id} + c_1 rand()(p_{id} - x_{id}) + c2Rand()(p_{gd} - x_{id})\ ]$$

$$K = 2 / |2-\varphi+\sqrt{\varphi^2 - 4\varphi}\ |$$

2.5 Heuristic Method

In the field of computer science, heuristic method is an artificial intelligence which is designed to solve a problem by finding the approximate solution when the existed method fails to find the exact solution. The purpose of heuristic method is to produce a solution for a problem which approximately same with the exact solution. The result from the heuristic method may not be the best but due to its time consumed to generate the solution is short and thus the result is still acceptable as the result approximate to the exact solution.

In heuristic method, there are two types of conditions which are: a set of variables that are not being attached and the half-way solution. For each iterations of the algorithms, it will try to convert the half-way solution into a complete solution which can solve the given problem. Once the algorithms start with the existed solution, it will loop until it reaches the maximum iterations or it has assigned all the variables.

```
procedure solve(unassigned, solution, max_iter)
  // unassigned is a list of un-assigned variables
  // solution is a partial solution (empty at the beginning)
  //     e.g. a list (variable, assigned value)
      iterations=0;
      while unassigned non empty & iterations<max_iter
            & non user interruption do
              iterations ++;
              variable = selectVariable(unassigned, solution);
              unassigned -= variable;
              value = selectValue(variable, solution);
              unassigned += assign(solution, variable, value)
                 // assign the variable and return violated variables
      end while;
      return solution;
end solve
```

Figure 2.1 Pseudo Code of Heuristic Method

The algorithms choose the value by passing through the variables. By going through each domain via the function stated in the algorithms, the value of the variable will be selected. The loop will continue until it finds the best fitness value.

2.6 Constraint

A hard constraint is the rule that need to be satisfied in a system. In the development of a system, the hard constraint needs to be stated clearly so that it will produce an optimum result. Time clashing is the hard constraint that needs to be fulfilled in this system. Both driver and vehicle are supposed not to be assigned into a same timeslot. In order to prevent time clashing, both driver and vehicle that have been assigned for work will not be selected in the process.

A soft constraint is the rule that should be considered in a system. The soft constraint in this project is the working hours of the driver. Although a driver can be assigned for work in a continuous timeslot, it is considerable that offer a resting timeslot for a driver after a particular timeslot. The resting hour of the driver will be considered depending on how many hours the driver has been worked for.

2.7 Comparison of Heuristic Method and Particle Swarm Optimization

Table 2.1 Comparison of Particle Swarm Optimization (PSO) Method and Heuristic Method

	Particle Swarm Optimization (PSO)	Heuristic Method
Simulation	Birds Flocking in a population	Mathematical Algorithms
Process	1. Generating particles position and velocity. 2. Update the velocity and the position. 3. Retrieve the best global position.	By evaluating the function, the search for the best solution is made in the algorithms. The evaluation function will update the existed solution to a better solution through the iteration in the algorithms.

The process of Heuristic method and Particle Swarm Optimization (PSO) is almost the same as both methods are also evaluating the function in order to search for the best solution of the problem. However, in PSO, there are simulating the problem as the particles in a search space and given their current best position in the search space. After that, it will generate the solution by adding velocity to the particle with current best position and a new position for the particles will be generated. The fitness value for the particles will be evaluated along with the velocity until it meets a condition to terminate the iteration and then the local best position will be generated. Next, the local best position will then be brought forward to be compared among the global to retrieve for the best global position which means the best solution among the population.

For heuristic method, there are search spaces as well but the process will go through all the possible solution to generate for a better solution. By applying the algorithms into the iterations, the function set will update the solution into a better solution and it will take time with the evaluating process.

2.8 Conclusion

As a result, in transport scheduling system, timetable generation should be efficient in term of time and usability. By using Particle Swarm Optimization (PSO) method, the timetable can be generated by choosing the particle (driver or vehicle) randomly so that it does not search one by one for the selection of driver or vehicle. Compared to Heuristic Method, the timetable that is being generated will need to search for every driver before a driver is selected for a trip which is not efficient. Thus, Particle Swarm Optimization method is chosen for generating the timetable of this Transport Scheduling System.

Chapter III

Methodology

3.1 Introduction

This chapter discuss about the methodology that is used for this system. Methodology in software development is used to control the process of a development. The type of methodology used is depend on the system as the correct used of methodology will efficiently produce the application.

3.2 Feasibility Study

Scheduling is an issue that is always been discussed in the computer field as arranging a timetable will be time consuming. It needs to consider a lot in order to create a timetable that can be used by the user without any clashing of time. A lot of timetabling studies have been carried out by using different kind of artificial intelligence techniques such as Graph Heuristic Method, Genetic Algorithms and so on. By applying the techniques, the system will help the user to create a timetable automatically after fulfil all the constraints that have been defined in the system.

3.3 Methodology

Methodology is the method used for a specific system. By having the flow of the methodology, the system is being developed from phase to phase and this will make sure that the system is being developed correctly before deployment. Methodology can be used as a guideline in a system so that the system can be developed with procedure. In this project, I would like to implement Rapid Application Development (RAD) method. With RAD method, the system will be developed efficiently as this method provide a more realistic and practical method during development.

3.3.1 Modified Rapid Application Development (RAD)

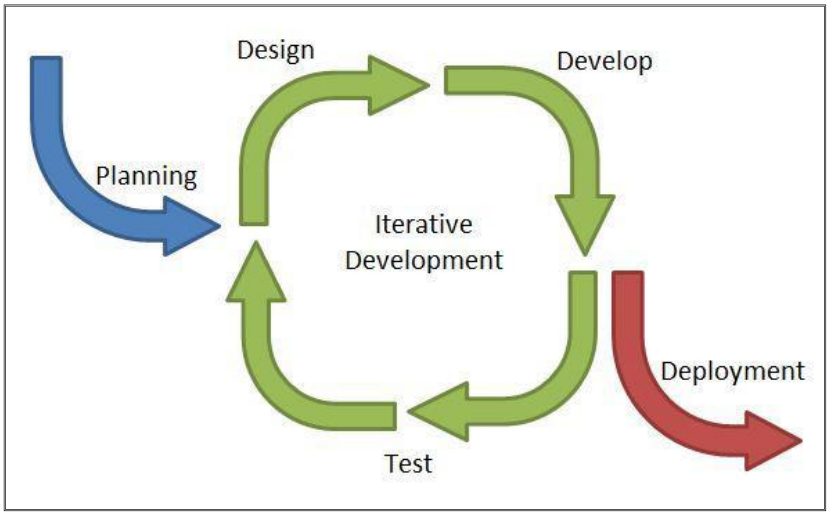

Figure 3.1 Rapid Application Development Model (Modified)

3.3.2 Planning Phase

This phase representing the starting phase of the system which requires understanding and getting the requirement of the system. During this phase, research has been done in order to be implemented into the system. Variety of artificial intelligence techniques and the requirements of the system have been studied for implementing into the system.

Besides, studies of timetabling for transportation which consists of suitable timeslot and working hour have been done in this phase. After that, selecting the suitable artificial intelligence techniques will be made after understanding the concept of conducting a timetable.

3.3.3 Iterative development Phase

The main purpose of this phase is to handle any changes of the requirements on the system. This phase is created as a form of cycle which consists ofdesign, develop and test. At the beginning of the development, a prototype is design according to the user requirements and the flow of the system will be noted so that the development of the system can satisfy the user. After the sketch of the design is created, development phase will start in order to create a system which will be used by the user. Next will be the testing phase which will test for the usability and functionality of the system after the system has been developed. At this phase, the user can check the system whether the system fulfil their requirements.

3.3.4 Deployment Phase

This phase will only be done after the system is completely developed and full testing has been carried out on the system and this will make sure that the system that is created fulfil user requirements and does not contain major errors. This means that the system can be deployed at the user site.